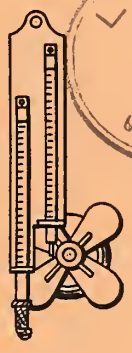
TECHNICAL EQUIPMENT REPORT NO. F-1

MAY 5, 1958

ELECTRIC FAN PSYCHROMETER

BY

DIVISION OF FOREST FIRE RESEARCH
INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
MISSOULA, MONTANA



U.S. FOREST SERVICE
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FOR

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Division of Forest Fire Research
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Forest Service, U. S. Department of Agriculture
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Introduction

This equipment development report covers the development of a new electric fan psychrometer designed to replace the psychrometers currently used by field personnel.

One of the three most important weather measurements taken at forest fire-weather stations is relative humidity. This information is obtained from a psychrometer, which consists of a wet and dry bulb thermometer. Moving air past the moistened wicking of the wet bulb thermometer causes evaporation; this in turn lowers the temperature reading of the thermometer. The difference between the wet and dry bulb temperatures indicates the relative humidity, which is read from a table.

Most fire-weather stations measure humidity with either a hand-crank psychrometer or a sling psychrometer. Both types are manually operated. The hand-crank unit creates wind by using a hand-driven fan. The sling psychrometer uses a whirling motion to create the effect of wind. Both devices are satisfactory when used correctly, but they are susceptible to human error which may result in erroneous relative humidities.

Hand-crank fans were designed more than twenty years ago. Since then, each renewal order has required special tooling by a contractor, for none of the components are available on the open market. Several units currently used are in poor condition and should be replaced (fig. 1).

Many sling psychrometer tubes are broken by inexperienced field personnel; this causes unnecessary cost and lost humidity information. The two types generally used differ only in size and require the same whirling motion to aspirate the moist wicking. The tubes and metal mountings of the larger sling psychrometers are used on the hand-crank units; a piece of 1/2 inch strap iron holds the psychrometer to the wooden base.

Objectives

1. Modernize humidity measuring instruments.
2. Design a unit that uses components available on the open market.
3. Increase ease of handling by the observer.
4. Obtain consistent and reliable data by reducing the chance of human error.
5. Design a low-cost unit that will give long service.

Figure 1. A hand-crank fan with broken blades.

Considerations

In order to have the maximum depression of the wet bulb thermometer, a minimum air displacement of 12 feet per second must flow past the moist wicking. Any amount of wind less than that is likely not to lower the wet bulb temperature to its correct value. This, of course, would give an erroneous relative humidity. When using manual psychrometers, inexperienced field personnel often do not create enough wind for a long enough period of time to depress the wet bulb temperature to its proper point. To avoid this error, development of an electrical fan aspirator was necessary.

History of Development

A preliminary study of the market soon showed that many types of psychrometers are commercially produced. In light of the considerations mentioned above, continued use of the strictly manual-type psychrometer was regarded as not feasible. Other products were too elaborate and costly for practical usage. Various types of humidity indicators seemed to show much promise, such as thermistors (or thermal resistors), which have a high negative coefficient of resistance. However, electronic and electrochemical measurement methods did not appear feasible for servicewide use at this time. Psychrometers were already available at fire-weather stations; therefore, the simplest and cheapest procedure was to use instruments on hand.

With this decision made, it was then necessary to find a suitable substitute for the hand-crank fan. In the spring of 1955, several types of small electric motors were bought and tested along with different makes of fan blades. The combination blade and motor had to displace a minimum of 12 feet per second air movement past the wicking of the wet bulb thermometer. In addition, the motor had to be powered by a 6-volt dry cell, have a low current drain, and have long life under severe field conditions.

During the first tests, electric timers were used to run the motors for 2-minute periods; however, this use of timers was later abandoned as impractical for field purposes. Some motors were rejected because they used more than 1.5 amperes, which would drain a dry cell too fast. Others were eliminated because they did not operate efficiently in a voltage range of 4.0 to 6.0 volts; this stipulation was necessary to assure proper air flow even when a battery was old and weak.

Further testing proved that the motor bushings had to be metal or nylon; otherwise, they would wear quickly. Those motors with cardboard or fiber bushings were rejected. Several motors that functioned well were not completely encased and were therefore susceptible to weathering. Other motors had spring-metal brushes, which did not appear as desirable as carbon or silver-graphite brush tips.

Several types of fan blades were tested. A 4-bladed fan, clockwise rotating, plain finish, with an over-all diameter of 3 inches, proved to be the most suitable. The hub of the fan blade did not fit the motor shaft; however, a special bushing corrected the situation. Other blades that fit the motor shaft could be purchased, but the blade chosen was the most economical.

By the winter of 1955, a motor and fan blade combination was decided upon as a result of the tests. Since the electric aspirator fan was to replace the hand-crank fan on the standard psychrometers currently used, a "Fan Psychrometer Conversion Kit" was developed. This kit

consisted of an installation template, an electric motor, a fan blade and bushing, an aluminum mounting, a toggle switch, screws, and appropriate wiring (fig. 2). After removing the hand-crank fan from the wood base, field personnel could mount the new unit with the aid of the installation template. A 6-volt dry cell was the power source.

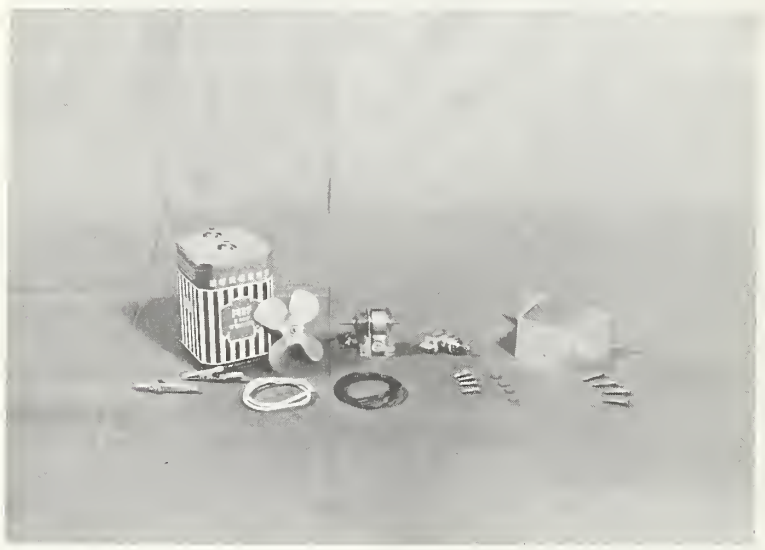

Figure 2. Parts of the "Fan Psychrometer Conversion Kit."

In the spring of 1956, the Forest Service warehouse in Spokane, Washington, made 25 conversion kits for Regions 1 and 4. These units were tested that summer, and they all worked satisfactorily (fig. 3).

A method was described for converting a sling psychrometer into a modified standard USFS fan psychrometer unit. In addition to the kit and psychrometer, only a wood baseboard, a piece of 1/2-inch strap iron, and a water bottle were needed. The installation template gave the proper relationship of the fan unit, the water bottle, and the psychrometer tubes. After constructing the proper wood base, the procedure was to mount the sling psychrometer on the metal strap, then screw the psychrometer unit and the fan unit to the wood base (fig. 4). Complete directions were included in the installation kits.

Figure 3. An electric fan on a converted hand-crank psychrometer. Notice the sling psychrometer tubes mounted in front of the fan.

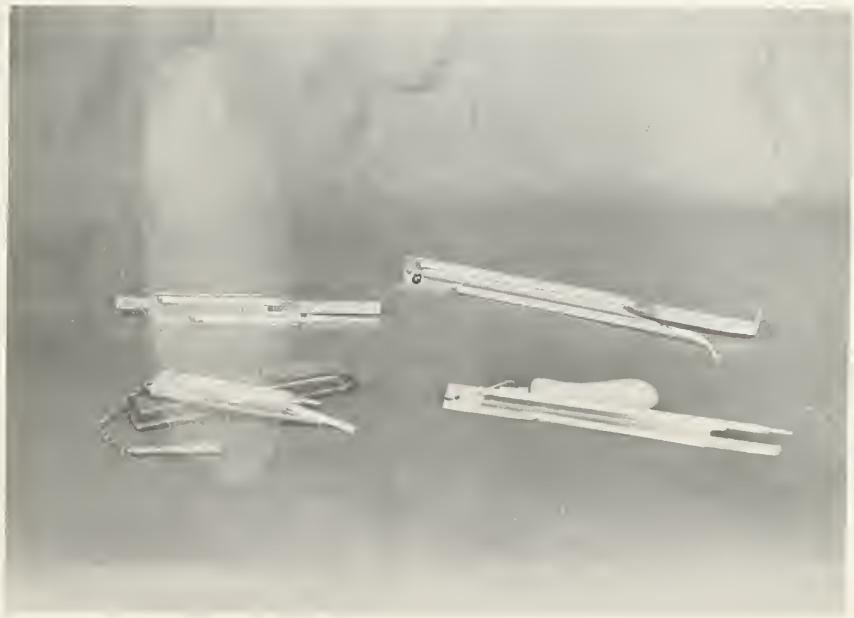

Figure 4. Sling psychrometer mounted on metal strap iron in the back. Notice the two sizes of sling psychrometers in front. The thermometer tubes were broken in field use.

A second order of "Fan Psychrometer Conversion Kits" was made in the spring of 1957. More than 250 units were field tested that summer. The only failure was the cracking of one plastic motor housing. During this time, sling psychrometers or hand-crank psychrometers were converted to electric fan psychrometers; but no completely new fan psychrometer units were purchased.

Results

The electric fan psychrometer has proved satisfactory in field tests for two fire seasons. Laboratory tests showed that the electric fan blows more than the required amount of air displacement even when the operating voltage dropped to 4.0 volts. Endurance tests were made with the unit running continuously for 8 hours. Then the motor was tested by running it from an OFF position to maximum speed 1,500 times. The results of the endurance tests proved that the electric fan unit is sturdy and can have a long life with proper care. A very small drop of oil on the bearings assures proper maintenance.

The electric fan costs less than the hand-crank fan. All the components, except for the aluminum mounting, are available on the open market. An entire setup, including a modified sling psychrometer, can be assembled for approximately $10.00. The "Fan Pyschrometer Conversion Kit" costs about $4.50.

Recommendations

We advise replacing all hand-crank fans with electric fans. Also, we recommend converting sling psychrometers to electric fan pyschrometers.